# Spatial variation of participants' coverage in participatory mapping

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Originally published at:
Rohrbach, Beni; Laube, Patrick (2014). Spatial variation of participants' coverage in participatory mapping. In: GIScience 2014: Eighth International Conference on Geographic Information Science, Vienna (A), 23 September 2014 - 26 September 2014. Department of Geodesy and Geoinformation Vienna University of Technology, 390-395.

# Spatial variation of participants' coverage in participatory mapping

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## 1. Introduction

We present methods to account for the spatial variation of the participants' individual coverage in participatory mapping. Participatory mapping is the process of gathering information in Public Participatory GIS or Participatory GIS. Our studies on participatory mapping revealed a noticeable spatial variance in the participants' coverage when mapping: Some participants even explicitly did not consider some parts of the study area. In this paper we therefore present methods to account for such spatial variation among participants' coverage. The methods were developed and tested around a case study investigating the expected change in extent and of spatial distribution of vineyards in the next decades.

## 2. State of the Art

Sampling strategies in participatory mapping range from casual to purposive. They might be random (Tyrväinen et al. 2007), include volunteers (Brown et al. 2013), represent communities (Alessa et al. 2008), aim at highest diversity of opinions (Debolini et al. 2013) or include selected experts (Yates and Schoeman 2013). However, no known sampling strategy explicitly considers the spatial variation of participants' familiarity within the area of research.

There are several methods to aggregate the spatial expressions of the participants' opinions in participatory mapping. The majority of studies is based on the placement of point markers and subsequent kernel density estimation (Alessa et al. 2008). Other studies ask to map polygons and then count the number of overlaps to highlight converging opinions (Black and Liljeblad 2006), use dot density shading (Montello et al. 2003), or apply a spatial union emphasizing the range of opinions (Morse et al. 2014). But there is no known method to show the range of opinions while still highlighting hotspots.

## 3. Case study: Expected changes in viticulture

### 3.1 Area of investigation

The area of research lies in the alpine canton "Wallis", in southern Switzerland, covering five municipalities (c.f. Figure 1). There, the viticulture is a dominating landscape element, but is expected to change in the near future (Koder 2014). The steep landscape dominated by dry stone walls, as visible in Figure 2, requires much manual labor.

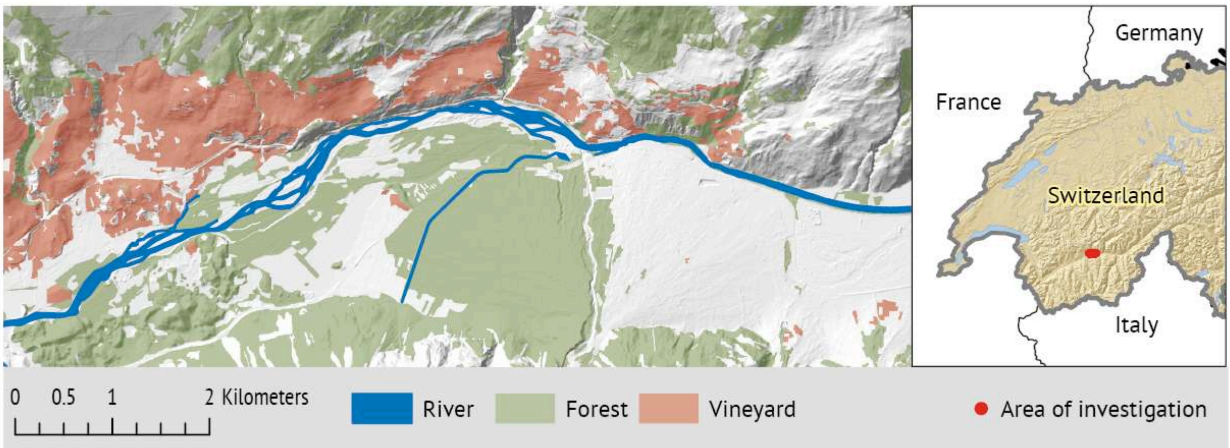


Figure 1: Location of the area of investigation and therein the vineyards

Figure 2: Impression from the area of investigation

### 3.2 Sample

The study investigated the mapping of the expected land-use change in the area. Therefore, we targeted wine-farmers, wine producers, and people that grow grapes as a hobby; approximately 150 candidate participants in the area. A first set of participants was selected in cooperation with a local expert. Additional participants were selected randomly and contacted by telephone, yet others were approached directly in the field. Eventually, 32 participants could be interviewed in person. 5 of the 32 refused to complete the mapping task and one participant covered an area not analyzed further here, resulting in a 26 individual maps containing a total of 288 polygons. Participants were on average 50 years old, with over 25 years of experience in viticulture.

### 3.3 Participatory mapping

The mapping itself was low-tech, low-cost, and reliable, similar to the procedure suggested in Mather et al. (1998). Orthophotos at the scale of 1:5000 on different A3-sheets served as mapping ground, which covered a total area of about 35 km$^2$. To familiarize the participants with the area, they were first asked to mark their own land. Then they were asked to map areas they think will not be used for viticulture anymore in 10 to 15 years from now. The maps were scanned, image processed, georeferenced and then vectorized. The resulting data was processed using FME, qGIS and ArcGIS.

## 4. Aggregation method

First, we assessed the overlap between participants. To do so, the polygons of all participants were overlaid and the number of overlaps was counted. This yields a **density map of opinions** (Figure 3) as known from Black and Liljeblad (2006). Second, we normalized the number of people marking a given area. For normalization, we used the number of participants covering an area in the first place. Therefore, we calculated the area covered by each participant out of all polygons marked by this participant using three different methods: A) The convex hull, B) the concave hull, also known as α-shapes (Edelsbrunner et al. 1983) and C) multiple buffers, resulting in a field-like density surface. In all three methods, the initially mapped shapes were buffered with 50m. This buffer corresponds to the average parcel width in the area and servers as a proxy for the participants' "visual roaming" whilst marking their polygons. The convex hull is a parameter free method. The concave hull requires the setting of an α-value, which we set to 100m after an initial sensitivity study, which roughly corresponds to a "natural" maximal distance between viticulture patches in the area. In the multi-buffer-field method, we used 10 buffers with a distance of 50m each, with the coverage value declining with increasing distance from 1 ("fully covered") to 0.1 ("still somewhat covered"). Summing the coverage of all participants yields the **coverage density map** (Figure 4).

Finally, the density map of opinions was intersected with the coverage density map. Then, we divided the number of opinions by the coverage, resulting in an **agreement map**. Thus, an area covered by 10 and marked 3 participants results 30% agreement among the participants while an area covered by 3 participants and marked by all 3, results 100% agreement. For clarity, areas marked by only one participant are not displayed in Figure 3.

## 5. Results

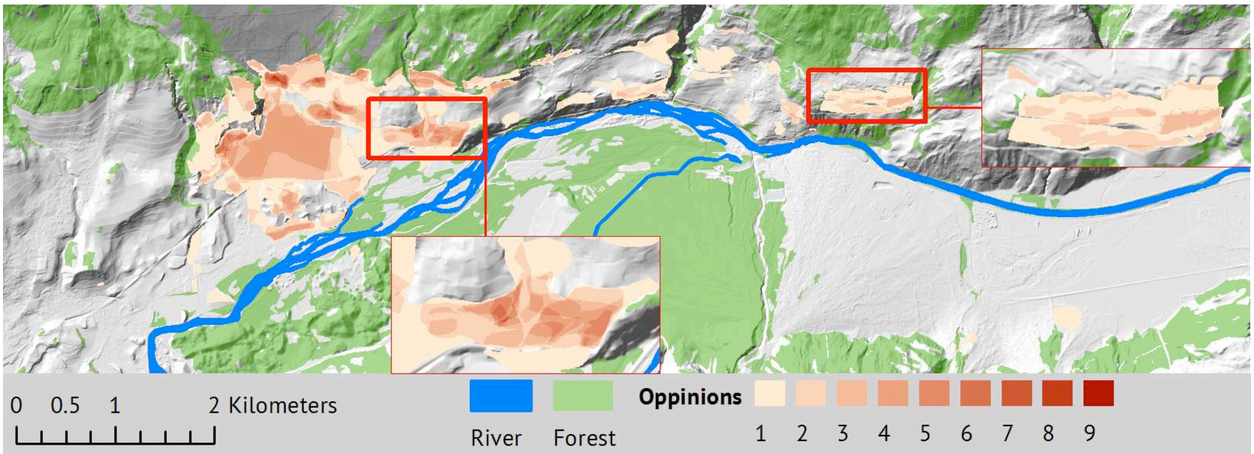


Figure 3: Opinions density map

The data shows a rather low degree of agreement and a strong separation of covered areas among participants. Many participants made statements only about parts of the valley, often about their own municipality. Figure 4 compares the different aggregation methods. The first row illustrates the different methods to estimate the area covered by each participant, and the second row the respective coverage density maps. The third row shows the resulting agreement map. To highlight the differences between the methods, selected parts are zoomed to.

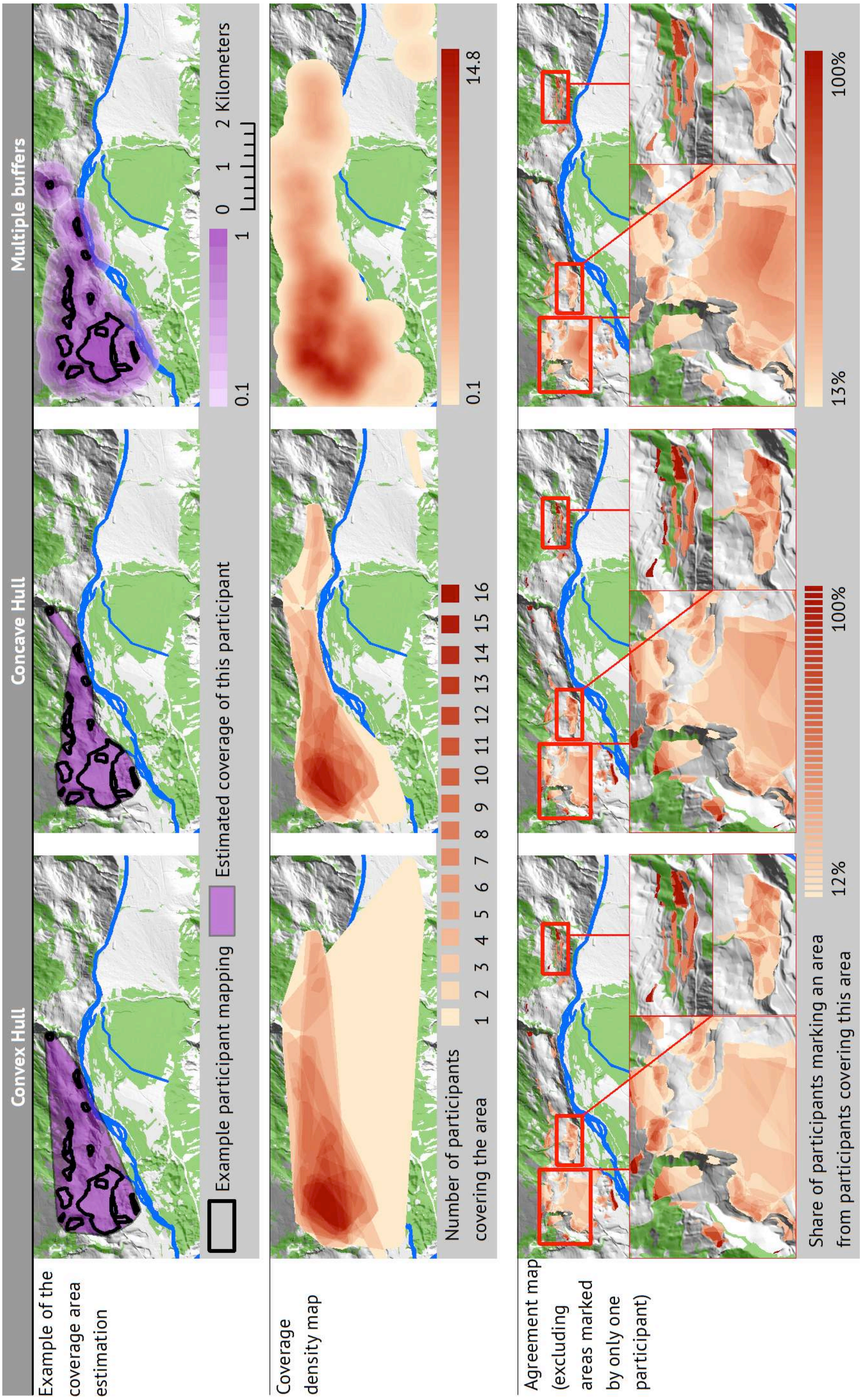


Figure 4: Normalizing the opinion density with the coverage density

## 6. Discussion

Although different in details, the three suggested normalized aggregation methods deliver very similar results (Figure 4). When comparing the normalized aggregation with the conventional opinion density (Figure 3), important differences become evident. Areas that are only mapped by few participants appear to be of little importance in the density map, regardless how many participants covered this area. For example, the areas in the upper right inset map in the third row of Figure 4 indicate high agreement (50-100%) for all normalized aggregation methods, while Figure 3 shows a rather low number of participants marking that area (3-4). Hence, our study helps identifying such potential hotspots that would be overlooked using conventional aggregation.

The proposed methods to calculate the coverage density need further improvement. The convex hull method includes large areas that surely no participant considered. However, as this method is parameter free, it has its advantages. While the multiple buffer approach does smoothen out this effect, this must not be more accurate. Finally, the definition of parameters requires the involvement of domain experts. These parameters may depend on the audience, the communication channel, the mapped objects and the aim of the investigators.

## 7. Conclusions

The contribution of the proposed aggregation method for participatory mapping lies in its ability to show the hotspots of agreement among the participant, while taking the coverage density into account. This work stresses the need to consider spatial differences in coverage, not only for aggregation but as well for sampling.

## Acknowledgments

We would like to thank all the participants and the administration of the protected area “Pfyn-Finges” for their assistance. The University of Zurich funded this work.

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